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The Aggregate Cost of Deposit Insurance: A Multiperiod Analysis*

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This paper extends the standard single-period model of deposit insurance to a multiperiod setting. It incorporates a variety of features describing bank and regulator behavior, such as endogenous capital adjustments and regulatory forbearance. Budgetary costs of deposit insurance are found using contigent claims techniques. We show how the market value of a bank's net worth, a critical input of the model, can be estimated using accounting cash flow data and information from aggregate bank stock prices. Using Call Report data on U.S. commercial banks, we provide empirical estimates of the aggregate cost of deposit insurance under alternative regulatory policies. *Journal of Economic Literature* Classification Numbers: G13, G21, G28, H61.

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1. INTRODUCTION

Deposit insurance illustrates the conceptual and timing problems associated with budgeting for the cost of any insurance or credit program. In such programs, liabilities are incurred when the credit or insurance is extended, but cash payments may not be made until many years later. Federal deposit insurance dates from the 1930s, but payments for resolving failed depository institutions were small until the 1980s, when hundreds of insolvent thrift institutions were closed. The financial condition of the commercial banking industry also declined during the 1980s, although less drastically. Over this period, the Federal Government's liability for deposit insurance grew rapidly. However, Federal cash expenditures to resolve failed depository institutions lagged this cost increase. Expenditures were not required to cover losses of a failed institution and protect depositors until the decision was made to close it, usually well after insolvency. By the early 1980s, although hundreds of thrifts were insolvent, few had been closed. In some cases, years passed and losses multiplied before action was taken. By 1989, the aggregate cost of resolving insolvent thrifts exceeded $100 billion and overwhelmed the Federal Savings and Loan Insurance Fund.

Some observers attribute the delay in closing insolvent institutions, and the resulting run-up in insurance losses, to perverse political incentives that were reinforced by a flawed system of deposit insurance budgeting. By recognizing costs only when insolvent institutions were closed, Federal budgeting ignored the cost of extending insurance to operating institutions, insolvent as well solvent. Delaying the closure of insolvent institutions reduced the budgetary cost of deposit insurance, even though this action may well have inflated the present value of future losses. Only at the end of the 1980s, when insolvencies reached crisis proportions, were government officials forced to acknowledge these losses.[1]

Estimating the government's liability as it accrues should help to resolve this incentive problem. Had Federal budget conventions recognized accrued costs, reported budget deficits would not have been reduced by delaying closure. In addition, if budgets reflected the additional costs of delayed closure (regulatory forbearance), political incentives for postponing action would be diminished further.

While budgetary reforms will require political will, a satisfactory method for measuring the accrued cost of deposit insurance will be needed as well. Previous insurance valuation techniques are not designed to provide the

[1] Kane (1989) and Barth (1991) provide detailed explanations for the delay in closing insolvent institutions. Reports by the Congressional Budget Office (1991) and the U.S. Office of Management and Budget (1991) emphasize the need to reform deposit insurance budgeting to account for costs as they accrue rather than when payments are expended.

multiyear projections necessary for Federal budgeting. One goal of this paper is to provide an estimation technique for such accruals. Our method for estimating future deposit insurance losses can be used to assess the effects of changes in regulatory policy or deposit insurance premiums.

The approach developed in this paper differs from earlier work in that it identifies deposit insurance costs for the current and each future year. It also incorporates a variety of features describing bank behavior and regulatory policy, making it more general than previous deposit insurance models. In addition, since our objective is to provide estimates of aggregate deposit insurance costs, we must include the government insurer's liability for all banking institutions.[2] This poses difficulties because previous empirical estimates of deposit insurance costs have inferred a bank's financial condition from the market value of its shareholders' equity. This approach is infeasible when the cost of deposit insurance for all banks, including those with nontraded shareholders' equity, is required. Here, we develop an alternative technique that infers the financial condition of banks using both market value and accounting data.

In Section II, we develop a multiperiod deposit insurance valuation model. Given the parameters of the model, we show how to value deposit insurance costs using a Monte Carlo simulation. Section III describes techniques to estimate the model's parameters. Finally, Section IV provides year-by-year estimates of the budgetary cost of deposit insurance for U.S. commercial banks under alternative bank closure policies.

II. MODELING THE ANNUAL COST OF DEPOSIT INSURANCE

Robert C. Merton (1977) derived the value of fixed-term deposit insurance using the Black–Scholes (1973) pricing of European put options. We extend Merton's (1977) single-period model to a multiperiod context so that the value of renewable deposit insurance can be estimated not only for the first period, but for every subsequent period as well.[3]

[2] In valuing the aggregate cost of deposit insurance as the sum of the costs for individual banks, we assume that government actions taken at one bank do not affect the cost of insuring other banks. There are circumstances where this assumption will not hold. For example, the decision to close a particular bank could lead to losses at other banks that maintain correspondent balances. Also, if numerous bank closings have fiscal and/or monetary consequences that impact macroeconomic fundamentals, this could affect the cost of insuring other banks. However, it is important to emphasize that our technique for valuing the aggregate cost of deposit insurance permits correlation between banks' asset returns and their risks of failure, as would be the case when common macroeconomic risk factors affect banks. We only require that bank regulatory policies not alter the distribution of these macroeconomic risk factors.

[3] Other multiperiod models include Merton (1978), Pennacchi (1987b), and Acharya and Dreyfus (1989), but they do not separate the cost of deposit insurance on a period-by-period basis, nor do they include the bank and regulatory behaviors studied here.

The government's multiyear liability from providing deposit insurance can be defined as the sum of its liabilities from providing deposit insurance for each future year. Accordingly, its liability for a given future year can be defined as the present value of the program's operating expenses in that year. Thus, to calculate these yearly liabilities, a method of allocating the government's yearly operating expense is required. We employ the following procedure. The program's first-year liability equals the present value of payments needed to resolve all banks that become insolvent at the end of the first year.[4] Thus, this first-year liability is logically equivalent to that of providing insurance for one year only, since a program that terminates in one year would require the insurer to resolve all insolvent banks at year's end.

The liability from providing deposit insurance for the second year is then the present value of extending the program for one more year. This liability equals the *incremental* liability from insuring banks that were insolvent at the end of the first year but were not closed due to regulatory forbearance, plus the liability from insuring banks that were solvent at the end of the first year. Similar to the first-year liability, that of the second year presumes that any insolvent banks will be resolved at the end of the second year, as would be required if the program were terminated at that date. Likewise, the liability from providing deposit insurance for the third year equals the incremental liability from insuring banks that were insolvent at the end of the second year but not closed, plus the liability from insuring banks that were solvent at the end of the second year. Liabilities for subsequent years are defined similarly. An attractive feature of this multiyear cost allocation procedure is that regulatory forbearance does not change the cost of deposit insurance in the year that it occurs. Rather, it increases the subsequent year's cost of extending deposit insurance.

We assume that a bank's assets follow a continuous-time diffusion process in defining the following[5]:

$V(t)$ = the market value of a bank's assets, including any charter value associated with market power in lending or deposit issue, at the end of year t.

$D(t)$ = the value of a bank's deposits at the end of year t.[6]

[4] An insolvent bank is defined as a bank with a negative market value of net worth.

[5] Bank asset values are taken to be stochastic, but interest rates, the sole determinant of bank liability values, are assumed to be deterministic. At the cost of greater complexity, we could explicitly allow for interest rate risk, as in Pennacchi (1987a, 1987b). However, given that bank liability durations are typically short, we believe that the valuation effects of this assumption are minor.

[6] The term "deposits" is meant to include all of a bank's senior debt obligations. Subordinated (junior) debt is treated as capital, given that these debtholders bear losses ahead of the government.

σ_v = the standard deviation of the rate of return on a bank's assets.

δ = the bank's dividend payments per dollar of assets per unit time. These payments are assumed to be made continuously.

$x(t) = V(t)/D(t)$, a bank's assets per dollar of deposits.

r_T = the (annualized continuously-compounded) competitive market rate of interest on a zero-coupon default-free bond with a time to maturity of T years.

τ = the auditing interval of the deposit insurer, which is assumed to coincide with the period for which deposit insurance is budgeted, e.g., one year.

a = the government's administrative cost of auditing the bank, assumed to be incurred at the end of the year.

$\phi(x)$ = the probability that regulators will choose to close a bank when an audit reveals the bank's asset/deposit ratio equals x. This is a measure of regulatory forbearance.

k = the direct cost of resolving a failed bank as a proportion of the bank's negative net worth. This includes lawyers' and liquidators' fees, and losses due to the liquidation process itself net of any charter value that can be recovered and any losses borne by uninsured depositors or other nonsubordinated creditors.

n = annual growth rate of net new bank deposits.

h = annual deposit insurance premium per dollar of deposits.

$\gamma(x)$ = the amount of new capital issued per dollar of bank deposits.

Since the insurer's aggregate liability is the sum of its liabilities from insuring each bank, consider the insurer's multiyear liability for a particular bank. We start by deriving the insurer's liability from providing coverage for the first year only. This first-year liability equals the present value of payments needed to resolve the bank if it is insolvent at the end of the first year, as is assumed in Merton (1977). We next derive the insurer's liability from extending deposit insurance for each subsequent year, which depends on the probability distribution of the bank's assets at the start of each future year (as well as the bank not having been closed in a prior year). The insurer's liability for each future year is the present value of its contingent expenditures, which we compute using a Monte Carlo technique similar to that in Boyle (1977).

Let $G^T(t)$ denote the insurer's date t liability from providing deposit insurance over the year from date T-1 to T. Then $G^1(0)$ is the insurer's date 0 liability from providing insurance for the first year. Since we have defined this liability as the payments needed to resolve the bank if its net worth is negative at the end this first year, a modified Black and Scholes-type put option is the appropriate valuation formula. It is assumed that the bank pays a deposit insurance premium at the beginning of the year and that the parameters δ and k are constants. Thus, $G^1(0)$ is given by

$$G^1(0) = [D(0)N(-d_2^0) - e^{-\delta\tau}V(0)N(-d_1^0)](1 + k) + e^{-r_f\tau}a - hD(0), \quad (1)$$

where

$$d_1^t = \left\{\ln[e^{-\delta\tau}V(t)/D(t)] + \frac{1}{2}\sigma_v^2\tau\right\} \Big/ (\sigma_v\sqrt{\tau})$$

$$d_2^t = d_1^t - \sigma_v\sqrt{\tau},$$

$N(\cdot)$ is the normal distribution function, and $\tau = 1$ year. The term in brackets on the right-hand side of Eq. (1) is the formula for a Black–Scholes put option multiplied by the proportion $(1 + k)$, since we assume that the direct costs of failure increase at rate k with the bank's net worth deficit. The second term is the present value of the insurer's cost of auditing, and the final term reflects the value of the premium that the bank pays at the beginning of the period.[7] Since the deposit insurance premium is included in Eq. (1), $G^1(0)$ is the insurer's net liability for the first year. That value of h which sets $G^1(0)$ to zero can be defined as the "fair" price for deposit insurance for this year.

Next, the insurer's date 0 liability from extending deposit insurance to the bank for the subsequent (second) year, $G^2(0)$, can be computed. This depends on the bank not having been closed by regulators at the end of year 1. Given the bank's end-of-first-year asset–deposit ratio, $x(1) = V(1)/D(1)$, we specify the probability of closure as $\phi(x)$, which is assumed to be zero for $x > 1$ and a decreasing function of x for $x \leq 1$. A bank that, ex post, is closed at the end of the first year poses no further liability to the insurer, its cost being recorded in the prior year.

For a bank that, ex post, is not closed but is insolvent ($x(1) < 1$), the insurer's liability for the next year is the incremental cost of extending deposit insurance for another year relative to the cost of having closed the bank. Likewise, for all solvent banks ($x(1) \geq 1$), the insurer's liability for the next year is the cost of extending this insurance for one more year. For all banks that remain open, our modeling also incorporates assumptions regarding deposit growth, the size of the insurance premium paid by banks, and the degree of regulatory conrol imposed on banks through required

[7] Note that $V(0)$ is defined as the value of the bank's assets following payment of its deposit insurance premium.

changes in their capital level. These changes are assumed to occur discretely at the end of the year.

To illustrate this process, let $V(1^-)$ and $D(1^-)$ be the values of the bank's assets and deposits at the end of year 1 but prior to the start of year 2, and let $V(1^+)$ and $D(1^+)$ be the values of bank assets and deposits just after the start of year 2. These variables satisfy

$$D(1^+) = (1 + n)D(1^-) \tag{2}$$

$$\begin{aligned} V(1^+) &= V(1^-) + (n - h)D(1^-) + \gamma(x(1^-))D(1^-) \\ &= V(1^-) + [n - h + \gamma(x(1^-))]D(1^-). \end{aligned} \tag{3}$$

Equation (2) specifies a discrete increase in new bank deposits, where n is the assumed annual growth rate. Equation (3) states that the value of bank assets is augmented by the increase in new deposits less payment of a deposit insurance premium, plus the addition of new capital issued by the bank, $\gamma(x)D$. There are a number of possible functional forms for $\gamma(x)$, which captures the interaction between the bank and its regulators in determining new capital issues. The form that we use is one proposed by Furlong (1992), which assumes that banks partially adjust bank capital toward a target level.

Given values of $D(1^+)$ and $V(1^+)$, one can then compute the value, at the beginning year 2, of extending deposit insurance for this second year, $G^2(1)$. If a bank was insolvent at the end of year 1, the incremental value of extending deposit insurance is

$$\begin{aligned} G^2(1) = {} & [D(1^+)N(-d_2^{1^+}) - e^{-\delta\tau}V(1^+)N(-d_1^{1^+})](1 + k) + e^{-r_f\tau}a - hD(1^-) \\ & - [D(1^-) - V(1^-)](1 + k). \end{aligned} \tag{4}$$

The first three terms on the right-hand side of Eq. (4) are similar to those found in Eq. (1). The fourth term is the bank's (negative) net worth and direct closing costs if the bank had been closed at the end of the first year. Thus, Eq. (4) gives the incremental cost of extending insurance to this insolvent bank, relative to having closed it in the prior year.

If a bank is solvent at the end of year 1, the value, at the beginning of year 2, of extending deposit insurance for year 2 is simply

$$G^2(1) = [D(1^+)N(-d_2^{1^+}) - e^{-\delta\tau}V(1^+)N(-d_1^{1^+})](1 + k) + e^{-r_f\tau} - hD(1^-). \tag{5}$$

Since Eq. (4) and (5) are conditional on bank asset and deposit values at the end of year 1, rather than present (date 0) values, a method for finding the present value of these future contingent insurance costs is required. A Monte Carlo technique introduced by Boyle (1977), based on the valuation theory in Cox and Ross (1976), is used. This procedure generates a distribution of end-of-year asset–deposit values that determines a distribution of deposit insurance costs. Discounting this distribution of costs provides a present value of the cost of extending deposit insurance.

Cox and Ross' (1976) "risk-neutral" valuation approach states that the expected rate of return on all assets can be set equal to the risk-free interest rate if the expected value of all future contingent deposit insurance costs generated by these asset processes are also discounted by this risk-free interest rate. Hence, in generating a Monte Carlo distribution of values for $x(1^-) \equiv V(1^-)/D(1^-)$, we assume that the assets of the bank, V, follow the process

$$dV(t)/V(t) = (r(t) - \delta)\, dt + \sigma_v\, dz_v, \tag{6}$$

while the bank's deposits are assumed to follow the deterministic process $dD(t)/D(t) = r(t)\, dt$. From Itô's lemma, we know that the simulated distribution of the bank's end-of-year asset/deposit values will be such that $\ln[x(1^-)] \equiv \ln[V(1^-)/D(1^-)]$ is normally distributed with mean $\ln(x(0)) - (\delta + 1/2\sigma_v^2)$ and variance σ_v^2. Since $D(1^-)$ is nonrandom, each Monte Carlo simulation determines an end-of-year value for $V(1^-)$. If according to the closure rule, $\phi(x(1^-))$, the bank remains in operation, Eqs. (2) and (3) then establish values of $V(1^+)$ and $D(1^+)$.[8] In turn, these asset and deposit values determine $G^2(1)$ according to Eq. (4) or Eq. (5) for this particular random realization. Repeating the procedure for numerous simulation realizations produces a date 0 expected value for the second-period deposit insurance cost, $E_0[G^2(1)]$.[9] To find the date 0 value of deposit insurance for this second year, $G^2(0)$, the risk-neutral valuation approach requires that we discount by this one-period risk-free rate to obtain

$$G^2(0) = e^{-r_1}E_0[G^2(1)]. \tag{7}$$

To find the date 0 value of extending deposit insurance coverage to year 3, the procedure for year 2 is repeated, except that the values $x(1^+)$ from the first set of simulations become the starting values for a second set of Monte Carlo simulations that generate a distribution of risk-adjusted values

[8] If the simulation results in a value of $x(1^-)$ that specifies that the bank is closed, $G^2(1)$ is set to zero, i.e., a closed bank imposes no additional liability upon the insurer.

[9] More precisely, this is the expected value of $G^2(1)$ given the transformed (risk-neutral) asset-price process, which is not necessarily equal to the expected value of $G^2(1)$ for the true (actual) asset-price process.

for $x(2^-)$. The procedure can then be repeated for all future years. More generally, the date 0 value of the Tth year's deposit insurance is given by

$$G^T(0) = e^{-(T-1)r_T}E_0[G^T(T-1)]. \tag{8}$$

Given that the deposit insurance program is an unlimited-term contract, the present value of operating this program for all future years is

$$G(0) = \sum_{i=1}^{\infty} G^i(0). \tag{9}$$

Equations (8) and (9) are measures of the deposit insurer's liability for an individual bank. The insurer's aggregate liability for year T is computed by simply summing $G^T(0)$ over all banks. We now discuss the specification of the model's parameters used in our empirical work.

III. EMPIRICAL METHODOLOGY

The previous section derived a deposit insurer's multiperiod liability as a function of current bank asset and deposit values, the instantaneous variance of bank assets, and parameters that model bank and regulatory behavior. Some of these parameters are straightforward to calculate or have been previously estimated by other researchers. For example, for the FDIC's cost of a given bank audit, a, we use the 1987–1991 average level of FDIC administrative expenses per dollar of insured bank deposits, .000125, times the bank's insured deposits. A bank's dividend–asset payout ratio, δ, is set equal to the particular bank's dividend–asset ratio for the current year. For the direct cost of bankruptcy per dollar of negative net work, k, James (1991) estimates that approximately 1/3 of the cost of bank failures was attributable to direct expenses in closing them. Hence, we set $k = 1/3$.

We assumed that the interest rate on bank deposits was equal to $r =$ 3%, the approximate average for all deposits at the beginning of 1991. Thus, in between annual audits, deposits were assumed to grow at this deterministic rate. As specified in Eq. (2), banks also issue net new deposits at a rate equal to n at the beginning of each year. Since Baer and McElravey (1993) find that banks with adequate capital grow significantly faster than banks with capital deficiencies, we assumed a value of $n = 3\%$ for banks with positive net worth and of $n = 0$ for those with negative net worth. Thus, incorporating accrued interest and net new deposit issue, deposits in banks with positive net worth grow at approximately a 6% annual rate while those in unclosed banks with negative net worth grow at a 3% rate.

Our modeling of a bank's new capital also borrows from previous research. First, we assume that a bank increases capital to cover the capital deficiency resulting from its payment of a deposit insurance premium and from its issuance of new deposits, if any. More specifically, we assume an increase in capital per dollar of deposits of $h + (x^* - 1)n$, where $(x^* - 1)$ is defined as the bank's target capital to deposits ratio.[10] Second, we utilize Furlong (1992) to model how a bank with positive net worth adjusts its capital.[11] Furlong (1992) suggests that banks have a target capital–asset ratio that minimizes their total cost of finance, including costs that result from regulatory pressure. Because adjusting the bank's current capital–asset ratio to this target level is costly, the adjustment is assumed to occur only gradually. The partial adjustment process used is

$$\zeta_{t^+} - \zeta_{t^-} = \kappa(\zeta^* - \zeta_{t^-}), \tag{10}$$

where $\zeta_t \equiv [V(t) - D(t)]/V(t) = 1 - 1/x(t)$ is the bank's capital–asset ratio at time t, ζ^* is its target capital–asset ratio, and κ is the annual rate of adjustment. Using annual Call Report data for 1990–1991, Furlong (1992) estimates values of $\zeta^* = .0740$ and $\kappa = .1474$ for banks with assets exceeding \$1 billion and values of $\zeta^* = .0923$ and $\kappa = .0561$ for banks with assets between \$100 million and \$1 billion.[12]

We use Furlong's estimates and the form of $\gamma(x)$ implied by Eq. (10) together with our previous assumption that the bank raises sufficient capital to cover its current deposit insurance premium and deposit growth. Given that $\zeta_t = 1 - 1/x(t)$, it is straightforward to show that $\gamma(x)$ is given by

$$\gamma(x(t^-)) = h + (x^* - 1)n + \kappa(x^* - x(t^-))\frac{x(t^-)}{\kappa x(t^-) + (1 - \kappa)x^*}, \tag{11}$$

where $x^* = 1/(1 - \zeta^*)$.[13] Thus, Eq. (11) specifies the form for $\gamma(x)$ that we used in updating the bank's capital in Eq. (3).

[10] The reason for this assumption is twofold. First, it gives banks a steady-state capital–asset ratio that is independent of their assumed growth rate of deposits, n. Second, the dynamics of each bank's assets are independent of the assumed deposit insurance premium that it pays, h. As noted below and as reported in Table IV, V, and VI, this simplifies the computation of a bank's fair insurance premium.

[11] A bank with negative net worth is unlikely to raise new capital. Marcus (1984) shows that for a bank with sufficiently low capital and charter (franchise) value, a new capital issue would decrease the value of existing shareholders' equity.

[12] The estimates of $\kappa = .1474$ and $\kappa = .0561$ represent "half-lives" (the time it takes banks to reduce a capital deficiency or surplus by ½) of 4.3 years and 12.0 years, respectively.

[13] Since $x(t)$ is the bank's asset–deposit ratio while ζ_t is the bank's capital–asset ratio, the form of the partial adjustment process for $x(t)$ is similar to that of ζ_t but includes the multiplicative term $x(t^-)/[\kappa x(t^-) + (1 - \kappa)x^*]$. This term is close to unity when $x(t^-)$ is close to the target level x^*.

To obtain estimates of the cost of deposit insurance, we also need the market value and rate of return variance of bank assets, and the rule used by regulators for closing banks. We now turn to these considerations.

III.A. *The Relation Between Cash Flows and Net Worth*

The market value and rate of return variance of a bank's assets, V and σ_V^2, respectively, are critical for determining the cost of deposit insurance. Unfortunately, they are not directly observable. Previous empirical studies relied on bank stock prices to infer these variables, but this method limits deposit insurance cost calculations to only those banks with actively traded stocks.[14] To calculate the total liability of a government insurer, it is important to estimate costs for all insured institutions. Thus, an approach capable of calculating deposit insurance values for every bank and thrift institution is desirable.

This section describes how quarterly Call Report data can be used to estimate the market values and rate of return variances of banks' assets. Individual bank holding company stock price data can also be used to help calibrate parameters that are not accurately estimated by classical statistical methods. As will be shown, our derived measure of net worth explains much of the variation in market equities for bank holding companies with traded stocks and is also highly correlated with FDIC loss estimates for failed banks.

Reported book values of assets held by depository institutions are unreliable measures of their current market values because standard accounting practice is to record loans and most other assets at their values when they are first placed on the balance sheet. Provisions for expected loan losses crudely adjust these book value measures toward their market values, often after a substantial delay. Changes in market value arising from interest rate risk are usually ignored. In contrast to balance sheet values, reported values of income and expense are relatively current and less biased, with two qualifications. First, reported income may include loan interest accrued but not paid, especially in the case of construction loans; but for most banks and thrifts this is a minor adjustment.[15] Second, because provisioning for losses tends to be erratic and subject to lags, especially when loan losses are rising, reported income in any period may be misleading. We attempt to overcome these problems by adjusting a bank's reported cash flows to

[14] These studies include Marcus and Shaked (1984), Pennacchi (1987b), King and O'Brien (1991), and Davis and Dale (1991).

[15] Banks, but not thrifts, report the current balance of income earned but not collected on loans as an asset. Eventually, this income will either be realized as cash or be written off as uncollectible. At the end of 1990, the average value of this asset as a proportion of total assets was 0.6% for banks with assets exceeding $500 million.

provide a more accurate picture of its financial condition. After adjusting these cash flows, we then estimate their stochastic process. Discounting the expected cash flows implied by this process results in our estimate of bank net worth. By exploiting cash flows' quick response to changes in financial condition, this method can lead to improved estimates of market net worth.[16]

Appendix A shows how a bank's ratio of net worth to deposits, $x(t) - 1$, can be calculated from suitably adjusted bank cash flow data. In summary, a bank's adjusted cash flow during period t, $C(t)$, is defined as

$$C(t) = \frac{y_t V_{b0}}{V_{bt} D_{b0}} - \frac{e_t}{D_{bt}}, \tag{12}$$

where V_{bt} and D_{bt} are time t book values of assets and deposits, respectively, y_t is the bank's one-period revenue from assets beginning at time t, and e_t is the bank's one-period deposit (interest and noninterest) expense beginning at time t. Time $t = 0$ is defined as a prior base period when the variables' market values were assumed to equal their book values. Cash flows are assumed to follow the autoregressive process[17]

$$C(t + \Delta) = \theta + \rho C(t) + \varepsilon_t,$$

where ε_t is a serially uncorrelated, mean zero random variable with variance σ_ε^2. The parameter ρ is a measure of the persistence of bank cash flows, with $\rho = 1$ being a random walk. For $\rho \in [0, 1)$, $C(t)$ reverts to its unconditional mean of $\theta/(1 - \rho)$. Given this cash flow process, the ratio of a bank's market value of net worth to the book value of its deposits, denoted $W(t)$, is

$$W(t) = \frac{\rho}{\pi - \rho} C(t) + \frac{\theta\pi}{(\pi - 1)(\pi - \rho)}, \tag{14}$$

where $\pi \equiv (1 + r)^\Delta$ is a competitive risk-free return over a period of

[16] A potential problem with using cash flow data to infer a bank's net worth may result when deposit insurance is mispriced. If banks are charged unfair deposit insurance premiums and the resulting subsidy is not passed on to borrowers, depositors, or other customers of the bank, the bank's net worth will reflect the value of this subsidy. Hence, it may be difficult to estimate the market value of a bank's assets minus the value of its deposits without contamination by a possible deposit insurance subsidy.

[17] By estimating an (AR)(1) process, we allow for the possibility of mean reversion in cash flows. This captures the empirical regularity that banks reporting extremely high or low earnings in one period may show earnings nearer the industry average in the next.

length Δ. It then follows that the one-period rate of return variance of $W(t)$ is

$$\mathrm{Var}_t[W(t + \Delta)] = \left(\frac{\rho}{\pi - \rho}\right)^2 \sigma_\varepsilon^2. \tag{15}$$

Equations (14) and (15) provide values for $x(t) = 1 + W(t)$ and $\sigma_v^2 = \mathrm{Var}_t[W(t + \Delta)]/\Delta$. The next section describes how bank accounting data are adjusted to calculate $C(t)$.

III.B. *Estimates of Bank Net Worth Using Cash Flow Data*

To calculate a bank's cash flow using Eq. (12), we first construct a measure of its revenue from assets, y_t. This is done by adjusting reported annual gross earnings (interest and noninterest income), denoted R_t, for estimated loan losses, denoted EL_{t+1}, and taxes, denoted T_t. Because a bank's provision for loan losses is erratic and more volatile than the future chargeoffs it is supposed to predict, we use an alternative predictor of future chargeoffs. This predictor was constructed on the assumption that chargeoffs are noisy measures of true loan losses of the previous year. Thus, an estimate of the current year's loan loss (using current year information) can be based on a forecase of next year's reported chargeoffs. This forecast was constructed using the relation

$$L_{t+1} = \lambda_0 + \lambda_1 NP_t + \lambda_2 L_t + \eta_t, \tag{16}$$

where L_t denotes net loan chargeoffs (chargeoffs minus recoveries) as a fraction of total loans in period t, and NP_t denotes the level of the bank's nonperforming loans minus its loan-loss reserves expressed as a fraction of total loans. We estimated Eq. (16) using a pooled time series of annual Call Report data for all banks with over \$100 million in deposits, for the period 1984–1990. Separate regressions were estimated for banks with over \$1 billion in deposits (large) and those with between \$100 million and \$1 billion in deposits (medium) to control for possible size-related differences. The results are displayed in Table I. The coefficient estimates for the two samples are similar, with the base rate of future chargeoffs, λ_0, being 43 to 46 basis points of total loans. Beyond this base rate, banks will typically add to next year's charge offs 18 to 21% of the current year's excess of nonperforming loans relative to loan loss reserves plus 50 to 60% of the current year's charge offs.

We used the predicted values of L_{t+1}, denoted EL_{t+1}, as a proxy for a bank's true loan losses for the current year, t. This proxy plus an estimate of corporate taxes (assuming a 30% percent tax rate), $T_t = .3(R_t - L_t -$

TABLE I
LOAN CHARGEOFF EQUATION PARAMETER ESTIMATES
$L_{t+1} = \lambda_0 + \lambda_1 NP_t + \lambda_2 L_t + \eta_t$
t statistics in parentheses

Sample	λ_0	λ_1	λ_2	Sample size	R^2
Large	0.0046	0.1757	0.6127	1047	0.37
	(11.9)	(9.4)	(19.9)		
Medium	0.0043	0.2104	0.5258	4418	0.38
	(18.6)	(21.0)	(35.1)		

e_t), we subtracted from bank revenues to give us the following measure of loan loss and tax-adjusted revenue

$$y_t = R_t - EL_{t+1} - T_t. \tag{17}$$

Given the revenue measure in Eq. (17), Eq. (12) was used to construct cash flows for all banks with deposits greater than \$250 million.[18] A pooled time series cross section regression using seven years of annual cash flow data could then be performed to estimate the cash flow process given by Eq. (13). However, upon analysis of banks' cash flow data, it was apparent that the volatility of cash flows showed systematic variation across large and small banks, as well as high and low cash flow banks. Hence, to allow for heteroskedasticity in the residuals for various categories of banks, we estimated Equation (13) using a two-stage least-squares procedure that allowed for differences in the variance of the residuals for large and medium-sized banks, as well as "stable" and "unstable" banks, where an unstable bank is defined as having at least one year of negative cash flow ($C_t < 0$) during the sample period.[19]

The resulting parameter estimates are reported in Table II, which clearly shows that the estimates of σ_ε in (13) vary considerably across bank categories. Note also that the estimate of $\rho = .9484$ is close to, but significantly different from, unity. Since $\rho = 1$ would indicate a random walk, this estimate implies that cash flows display mean reversion. This estimate of

[18] Banks with deposits between \$100 and \$250 million were excluded from the estimation due to a high frequency of accounting data errors for these smaller banks. While this subsample of banks represented $\frac{1}{2}$ of our total observations, they accounted for only 8% of total bank deposits.

[19] Our results confirm that cash flows were less volatile for large banks. Our reasoning for allowing a difference in earnings volatility for banks that experienced one year of negative cash flow was to allow for the possibility of moral hazard (excessive risk taking) by these weaker banks.

TABLE II
CASH FLOW EQUATION PARAMETER ESTIMATES
$C(t + 1) = \theta + \rho C(t) + \varepsilon_t$
Standard error in parentheses

Sample	θ	ρ	σ_ε	R^2	Sample size
Whole	0.00029[a]	0.9484 (.0144)		0.58	3096
Large stable[b]			0.0032		978
Large unstable			0.0112		362
Medium stable			0.0044		1314
Medium unstable			0.0151		439

[a] The estimate for θ was calculated by incorporating information from the market value of shareholders' equity for the 110 largest publicly traded banks and holding companies. This procedure is described in the text. The original two-stage least-squares estimate of θ equaled .00038 and had a standard error of .00017.

[b] Large banks are those with deposits exceeding $1 billion at the beginning of the sample period (1984). Stable banks are those reporting positive net income for every year of the sample period, 1984–1990. Unstable banks report at least one year of negative earnings.

ρ, together with the estimates of σ_ε, then allowed us to obtain estimates of σ_v for each of the four categories of banks using Eq. (15). These estimates are given in Table III.

As reported in a footnote to Table II, we obtained a two-stage least-squares estimate of $\theta = -.00038$ that was significantly different from zero. This point estimate is problematic since it implies that the unconditional mean of cash flows, $\theta/(1 - \rho)$, is negative, and, therefore, the unconditional mean of bank net worth also would be negative. The source of this problem is likely the relatively brief (and abnormally unprofitable) seven-year sample period that was used to estimate this long-run mean: it is simply too short a period to provide enough information on the cash flows.[20] To alleviate this problem, we used investor information, as reflected in traded bank shareholders' equities, to help infer the long-run mean of cashflows. Our methodology for incorporating this stock market based information is as follows.

For each of the 110 largest bank holding companies that reported a market value of shareholders' equity on Compustat, we calculated a theoret-

[20] It is well known that mean return parameters are difficult to estimate when using financial time series. As illustrated by Merton (1980), accurate estimates often require a long time period in order to separate out the effects of mean returns from the relatively large variance in returns that characterize this data. Our use of stock market data, which incorporates investors' views regarding mean returns, can be viewed as a Bayesian method of circumventing this problem.

TABLE III
ESTIMATED ANNUALIZED STANDARD DEVIATIONS OF THE RATE OF RETURN ON BANK ASSETS
$\sigma_V = (\rho/(\pi - \rho))\sigma_\varepsilon$

	Stable	Unstable
Large	2.3%	8.1%
Medium	3.2%	10.8%

Note. Parameter values of $\rho = .9484$ and $\pi = 1.085$ (the sample period mean of the 30-year Treasury bond yield) were used.

ical value of shareholders' equity for a given value of θ. This was done by first calculating each bank's net worth, using the discounted cash flow procedure described above and adding to it a proxy for the value of deposit insurance. Since a bank's shareholders' equity, E, equals its net worth plus the value of deposit insurance, we constructed this theoretical equity value using the equation

$$E = V - D + G^1, \tag{18}$$

where G^1 is the value of deposit insurance for the current year given by Eq. (1).[21] More specifically, given a starting value for θ, we first calculated each bank's net worth, V-D, for each quarter for 1985 through 1990 using Eq. (14) and its most current four quarters of cash flows.[22] These net worth values were then used to calculate G^1 from Eq. (1) and then the bank's theoretical market values of equity, E, from Eq. (18), for each quarter.[23] These theoretical bank shareholders' equity values were aggregated and the sample period value-weighted average was compared to the average actual market values of shareholders' equities obtained from Compustat for the same banks during the sample period. Iterating on the starting values for θ, this procedure was repeated until the theoretical average equity value equaled the actual average equity value. Following this procedure a value of $\theta = .00029$ was obtained. This translates into a long-run (uncondi-

[21] For tractability, we approximated the value of deposit insurance by using its first-year cost only, G^1, rather than the value for all future years. While this first-year cost is likely to represent a substantial part of the value of deposit insurance, this approximation will bias the value of net worth upward and bias subsequent deposit insurance cost estimates downward.

[22] In Eq. (14), the interest rate contained in the term $\pi \equiv (1 + r)$ was set equal to the prevailing 30-year Treasury bond yield for the quarter of comparison.

[23] The standard deviations of the rate of return on bank assets, σ_V, used to calculate G^1 are those given in Table III.

tional) value of net worth of 6.6% of deposits.[24] This estimate of θ along with our estimate of $\rho = .9484$ then allowed us to infer any bank's net worth, given its current cash flow, using Eq. (14).[25]

III.C. *Specifying a Closure Rule*

Regulators' behavior regarding bank closings can significantly affect the cost of deposit insurance. As Mailath and Mester (1994) illustrate, factors such as bank charter value, moral hazard, and the policy commitment of regulators can affect closure decisions. We do not model these numerous and often unobservable factors. Rather, we attempt to empirically determine a probabilistic closure rule, $\phi(x)$, that is assumed to be a logistic function,

$$\phi(x) = [1 + e^{\alpha_0 + \alpha_1 / x}]^{-1}. \tag{19}$$

The parameters of Eq. (19) were estimated using data on the Federal Deposit Insurance Corporation's (1992) estimated losses from failed banks for the 1985–1990 time period. At the start of each year in this period, we used our cash flow based estimates of net worth as starting values, along with the asset rate of return variances given in Table III, and produced a random distribution of year-end net worth values whose mean level matched the ex post industry average for that year.[26] For given values of α_0 and α_1, we compared our resulting cumulative volume of failed bank losses and average loss per closure to those two statistics actually reported by the FDIC for 1985–1990. Numerically iterating over α_0 and α_1, our simulated statistics fit those of the FDIC for the parameter values $\alpha_0 = 33$ and $\alpha_1 = -28$. The resulting closure probabilities are graphed in Fig. 1.

While Figure 1 shows that the likelihood of closure is an increasing

[24] Since the unconditional mean of $C(t)$ equals $\theta/(1 - \rho)$, Eq. (14) implies that the unconditional mean of net worth to liabilities is $\theta[\rho/(1 - \rho) + \pi/(\pi - 1)]/(\pi - \rho)$. A value of $\pi = 1.085$, reflecting the average 30-year Treasury bond yield for the sample period, is assumed.

[25] An analysis of the precision of our cash flow based model of net worth is given in Appendix B. There, we compare this derived measure to alternative measures of net worth for particular individual banks. We first examine the correlation and standard deviation of our derived measure of net worth with that implied by the market value of shareholders' equity for individual banks whose stocks are publicly traded. Second, we compare our derived measure of net worth to that implied by FDIC loss estimates at the time that failed banks are closed. In both cases, there is evidence that our model performs fairly well.

[26] For example, in 1985 the average net worth for the banking industry increased by 1.90% of deposits while average deposits grew 9%. Using Eqs. (2) and (3) and the fact that $\ln[x(t)]$ is normally distributed with standard deviation σ_v, simulations were performed so that the mean of our random distribution of net worths matched the actual industry mean. This process was repeated for 1986 using 1986 cash flow based estimates of net worth as starting values.

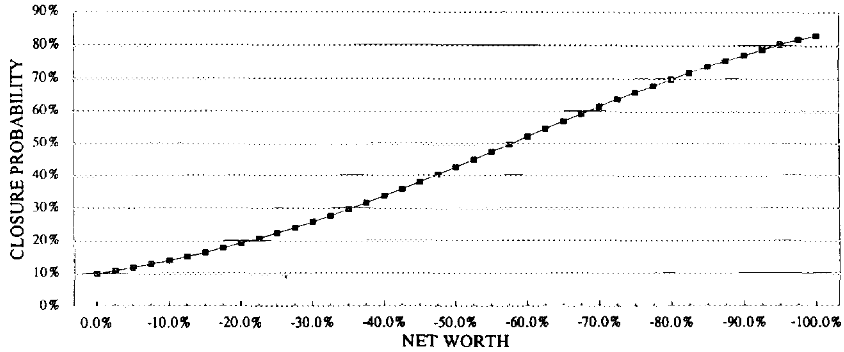

FIG. 1. Bank closure probabilities based on networth distribution, 1984–1990. The logit function was estimated using cash-flow-based net worth distributions of all failed banks with deposits exceeding $100 million.

function of negative net worth, the probability of closure is well below 100% for substantially insolvent banks. This conforms to recent experience that shows an average loss rate for failed banks of 15 to 20% of deposits.[27]

IV. RESULTING ESTIMATES OF DEPOSIT INSURANCE COSTS

The starting point for the Monte Carlo simulation method outlined in Section II is the year-end 1990 values of commercial banks' net worths, which are estimated using the cash flow based method described in Section III. Since our goal is to calculate the aggregate cost of deposit insurance, rather than detail the cost for each individual institution, Monte Carlo estimates are performed for all banks concurrently, using the following procedure.

Because larger banks account for a greater proportion of potential deposit insurance costs, estimates of the FDIC's cost for these institutions were based on a greater number of simulations than those for smaller banks. A total of 9,000 simulations were allocated across our sample of banks by bank deposit size. For example, a particular large bank that accounts for 1% of the $3.4 trillion of total commercial bank insured deposits and has a ratio of net worth to deposits equal to 4% would represent 90 simulations ($9000 \times .01$), each starting from 4% net worth.[28] While the accuracy of our

[27] See Federal Deposit Insurance Corporation (1992) and Appendix B.

[28] In order to maintain a stable distribution of bank sizes over time, we assume that a bank that is closed at the end of a given year is replaced with a new bank of the same size with a net worth equal to its appropriate target level, as estimated by Furlong (1992). (See Section III.)

TABLE IV
YEAR-END 1990 COST OF PROVIDING DEPOSIT INSURANCE OVER THE PERIOD 1991 TO 2010 ($ BILLIONS), USING HISTORICAL CLOSURE RULE

Year T (1)	Incremental annual gross cost G^I (1990) (2)	Bank deposits $D(T)$ All (3)	Bank deposits $D(T)$ Closed (4)	Gross FDIC losses $[D(T) - V(T)] \times (1 + k)$ (5)	Loss per deposit of closed banks (6)	Mean net worth for all banks $x(T) - 1$ (7)	Mean fair premium, $G^T(T)/D(T)$ (basis points) (8)
1991	$22.4	$2,449	$30.1	$3.9	13.0%	5.3%	91.5
1992	$4.8	$2,592	$28.6	$4.0	13.9%	5.2%	20.2
1993	$4.7	$2,745	$33.0	$5.1	15.4%	5.1%	20.3
1994	$4.9	$2,907	$45.1	$7.8	17.3%	5.1%	21.6
1995	$5.1	$3,078	$43.8	$6.4	14.6%	5.2%	22.9
1996	$5.1	$3,259	$46.9	$6.4	13.7%	5.2%	23.8
1997	$5.0	$3,451	$50.0	$7.0	14.0%	5.2%	24.1
1998	$4.7	$3,655	$51.6	$6.8	13.2%	5.2%	23.6
1999	$4.8	$3,870	$58.0	$9.2	15.8%	5.2%	24.6
2000	$4.6	$4,098	$49.9	$7.6	15.1%	5.3%	23.8
2001	$4.6	$4,339	$50.8	$6.7	13.2%	5.3%	24.9
2002	$4.3	$4,594	$66.4	$9.9	14.9%	5.2%	24.0
2003	$4.2	$4,865	$64.1	$10.0	15.6%	5.2%	24.1
2004	$4.2	$5,151	$71.8	$11.4	15.9%	5.2%	24.4
2005	$4.1	$5,454	$77.3	$10.9	14.0%	5.2%	24.3
2006	$3.8	$5,776	$84.2	$13.6	16.2%	5.2%	23.6
2007	$3.8	$6,116	$72.1	$10.8	15.0%	5.3%	24.0
2008	$3.8	$6,476	$76.5	$10.3	13.5%	5.3%	24.7
2009	$3.8	$6,856	$92.0	$13.6	14.8%	5.3%	25.2
2010	$3.6	$7,259	$88.1	$14.2	16.1%	5.3%	24.8
Sum	$106.2		$1,180	$176	14.9%		

deposit insurance cost estimates will be lower the smaller the bank, these errors would be a smaller proportion of total bank deposit insurance costs and will tend to cancel out when aggregated.

Using the Monte Carlo procedure described in Section II together with the parameter estimates described in Section III, Tables IV and V present the resulting estimates of the cost of deposit insurance based on year-end 1990 commercial bank financial data. Table IV assumes that banks are closed using our historically estimated closure rule described in Section III.C, while Table V assumes that all banks discovered to have negative net worth are closed immediately. In both tables, column (2) gives the year-end 1990 gross cost (excluding revenue from deposit insurance premiums) of providing deposit insurance for each year over the period 1991 to 2010. Columns (3) and (4) give the total deposits of all banks as well as the deposits of those banks that the model predicts will be closed at the end of the year. The fifth and sixth columns give the predicted FDIC losses and losses per deposits for these closed banks. The seventh column is the forecast average net worth per dollar of deposit for the banking industry, and the last column is the average annual deposit insurance premium that

TABLE V
YEAR-END 1990 COST OF PROVIDING DEPOSIT INSURANCE OVER THE PERIOD 1991 TO 2010 ($ BILLIONS), USING ZERO NET WORTH CLOSURE RULE

Year T (1)	Incremental annual gross cost G^{I} (1990) (2)	Bank deposits $D(T)$ All (3)	Bank deposits $D(T)$ Closed (4)	Gross FDIC losses $[D(T) - V(T)] \times (1 + k)$ (5)	Loss per deposit of closed banks (6)	Mean net worth for all banks $x(T) - 1$ (7)	Mean fair premium, $G^{T}(T)/D(T)$ (basis points) (8)
1991	$22.4	$2,449	$231.1	$22.1	9.6%	5.3%	91.5
1992	$1.3	$2,599	$74.6	$1.2	1.6%	6.5%	5.4
1993	$1.4	$2,758	$85.6	$1.4	1.7%	6.5%	5.8
1994	$1.5	$2,927	$100.0	$1.7	1.7%	6.5%	6.4
1995	$1.4	$3,107	$101.6	$1.8	1.7%	6.5%	6.4
1996	$1.4	$3,298	$115.2	$1.9	1.7%	6.5%	6.5
1997	$1.3	$3,500	$118.8	$2.0	1.6%	6.5%	6.3
1998	$1.3	$3,715	$119.8	$2.0	1.6%	6.5%	6.2
1999	$1.3	$3,943	$141.2	$2.4	1.7%	6.5%	6.4
2000	$1.2	$4,185	$135.0	$2.3	1.7%	6.5%	6.1
2001	$1.2	$4,442	$151.7	$2.6	1.7%	6.5%	6.3
2002	$1.1	$4,714	$155.8	$2.7	1.7%	6.5%	6.0
2003	$1.1	$5,004	$166.5	$2.8	1.7%	6.5%	6.1
2004	$1.1	$5,311	$179.1	$3.1	1.7%	6.5%	6.0
2005	$1.0	$5,637	$194.5	$3.4	1.7%	6.5%	5.9
2006	$1.0	$5,983	$201.8	$3.4	1.7%	6.6%	6.0
2007	$1.0	$6,349	$224.7	$3.8	1.7%	6.6%	6.0
2008	$0.9	$6,739	$228.8	$3.8	1.7%	6.6%	5.8
2009	$0.9	$7,153	$246.8	$4.1	1.7%	6.6%	5.9
2010	$0.9	$7,592	$263.6	$4.3	1.6%	6.6%	5.8
Sum	$44.5		$3,236	$72.9	2.3%		

would need to be charged in order to make the FDIC's net cost of providing deposit insurance equal to zero for that year.[29]

In comparing the results of Tables IV and V, note that the gross costs of providing deposit insurance for the first year, 1991, are the same ($22.4 billion). This reflects our logic that this cost should be invariant to regulators' decision of whether or not to allow insolvent banks to continue operation. Differences between the two tables emerge in the current (1990) cost of extending deposit insurance coverage past the first year. The results clearly indicate that a more lenient closure rule (Table IV) adds significantly to the cost of extending the deposit insurance program into future years. The year-end 1990 cost of using the historical closure rule for the next 20 years is more than double the cost of a zero net worth rule ($106.2 versus

[29] Because we assumed in Section III that banks raised capital to replace payments for deposit insurance premiums, the dynamics for banks' assets and liabilities are independent of the magnitude of these premiums. This allows for easy computation of a bank's yearly fair deposit insurance premiums, since the probability distribution of our simulations are unaffected by premium payments. While the realism of this independence assumption may be questionable, deposit insurance premiums are usually a small share of the yearly changes in bank assets and will have a relatively small effect on net worth.

$44.5 billion). This is also indicated in the last columns of the tables by the much larger fair deposit insurance premiums that would be needed to finance a more lenient closure rule (approximately 24 versus 6 basis points).

While over $2\frac{1}{2}$ times as many banks are predicted to be closed using the zero net worth rule versus the historical rule (column (4) of the tables), the FDIC's loss per closure is much less under this more stringent rule (column (6) of the tables). Not surprisingly (as is indicated in column (7) of the tables), earlier closure of insolvent banks leads to the banking industry having greater net worth (approximately 6.5% versus 5.3% net worth).[30]

Note that these deposit insurance costs reflect information available at the start of 1991. Since then, changes in market conditions and bank regulations have probably reduced insurance costs significantly. The net worth of the banking industry has grown following a two-year decline in market interest rates.[31] In addition, the November 1991 passage of the Federal Deposit Insurance Corporation Improvement Act (FDICIA) tightened regulation by establishing penalties for capital deficient banks and mandated that regulators take prompt corrective action, thereby reducing the scope of forbearance. To gauge the sensitivity of the model's estimates to influences such as these, we recalculated deposit insurance costs for a higher initial level of net worth and different parameter values.

Columns (2)–(4) of Table VI give annual deposit insurance costs, average net worths, and fair deposit insurance premiums for the same assumptions as those of Table IV except that all banks are assumed to start from net worth ratios that are 1% (100 basis points) greater than their year-end 1990 levels. The effect of this one-time capital increase is to reduce the 1990 total cost of deposit insurance from $106.2 to $89.9 billion.[32] From column (2) we see that most of the savings come in the early years, since banks' net worth ratios (column (3)) eventually converge to those in Table IV.

Columns (5) through (7) of Table VI present insurance costs, net worths, and fair premiums under the assumption that solvent banks adjust their capital toward target levels at a rate that is twice the rate estimated by Furlong (1992) and assumed in Table IV.[33] This behavioral change can be

[30] Note that these average levels of net worth, even for the zero net worth closure rule, are less than banks' target capital levels, as estimated by Furlong (1992). This is due to banks' assumed payment of dividends, δ, which, empirically, reduces average capital by approximately 40 basis points.

[31] See Table VII in Appendix B.

[32] Under the same assumptions but with all banks starting from net worth ratios that are 5% greater than their 1990 levels, the total cost of deposit insurance falls to $62.9 billion.

[33] In Table VI, the half-life for capital adjustments of large and medium banks is 2.2 and 6.0 years, respectively.

TABLE VI

YEAR-END 1990 COST OF PROVIDING DEPOSIT INSURANCE OVER THE PERIOD 1991 TO 2010 ($ BILLIONS), USING HISTORICAL CLOSURE RULE AND SPECIFIED PARAMETRIC ASSUMPTIONS

	1% extra initial capital			Double capital adjust rate			Stable σ_v for all banks		
Year T (1)	$G^T(1990)$ (2)	$x(T) - 1$ (3)	$G^T(T)/D(T)$ (4)	$G^T(1990)$ (5)	$x(T) - 1$ (6)	$G^T(T)/D(T)$ (7)	$G^T(1990)$ (8)	$x(T) - 1$ (9)	$G^T(T)/D(T)$ (10)
1991	$15.4	6.1%	61.8	$22.6	5.4%	90.7	$17.1	5.3%	68.5
1992	$3.8	5.9%	15.4	$3.6	5.4%	14.7	$2.1	5.3%	8.6
1993	$3.5	5.8%	14.9	$2.9	5.5%	12.0	$2.2	5.3%	9.4
1994	$3.7	5.7%	16.1	$2.6	5.6%	11.0	$2.4	5.3%	10.5
1995	$3.8	5.7%	17.2	$2.4	5.7%	10.8	$2.4	5.3%	10.9
1996	$3.9	5.6%	17.8	$2.4	5.8%	11.0	$2.6	5.2%	12.1
1997	$4.0	5.5%	18.9	$2.5	5.8%	11.6	$2.7	5.2%	12.8
1998	$3.9	5.5%	18.9	$2.4	5.9%	11.6	$2.8	5.1%	13.5
1999	$4.0	5.5%	20.3	$2.3	5.9%	11.7	$2.8	5.1%	14.1
2000	$4.1	5.4%	21.1	$2.3	5.9%	11.7	$2.7	5.1%	14.1
2001	$3.9	5.4%	20.5	$2.3	5.9%	11.9	$2.7	5.0%	14.3
2002	$4.0	5.4%	21.4	$2.2	5.9%	11.7	$2.7	5.0%	14.8
2003	$3.9	5.4%	21.7	$2.1	5.9%	11.5	$2.6	5.0%	14.8
2004	$3.9	5.4%	22.1	$2.1	5.9%	11.7	$2.6	5.0%	14.9
2005	$3.7	5.4%	21.8	$1.9	5.9%	11.3	$2.5	5.0%	15.1
2006	$3.7	5.4%	22.1	$1.9	5.9%	11.5	$2.5	5.0%	15.1
2007	$3.5	5.4%	21.9	$1.9	5.9%	11.4	$2.4	5.0%	15.0
2008	$3.5	5.4%	22.5	$1.8	5.9%	11.3	$2.3	5.0%	14.9
2009	$3.3	5.4%	21.5	$1.8	5.9%	11.4	$2.3	4.9%	15.3
2010	$3.2	5.4%	21.7	$1.7	5.9%	11.5	$2.2	4.9%	14.9
Sum	$89.9			$65.5			$64.6		

Note. $G^T(T)/D(T)$ in basis points.

thought of as capturing the greater penalties for capital deficiencies imposed by the 1991 FDICIA. More rapid capital adjustment lowers total insurance costs from $106.2 to $65.5 billion. Unlike the previous case, most of the savings come in later years when less banks become insolvent. This leads to a higher steady-state level of capital since fewer banks become trapped in an insolvent state where, by assumption, they are assumed to be unable or unwilling to issue new capital.

We consider one last parametric change where the asset variances of unstable banks are reduced to those of stable banks so that all banks have asset rate of return volatilities given by the first column of Table III. This attempts to model more stringent regulatory policy that reduces moral hazard of financially distressed banks. As columns (8)–(10) of Table VI indicate, this parametric change reduces total insurance costs from $106.2 to $64.6 billion. However, the steady-state level of capital for the industry (column (9)) is lower than the benchmark case in Table IV because banks that become moderately insolvent tend to remain in that state for a longer period of time. Because the (historical) probability of closure increases with the degree of insolvency, banks with lower asset risk will be less likely to experience a large negative return that would increase their likelihood of closure. In addition, they will be less likely to experience a large positive return that would restore their solvency.

V. CONCLUSION

This paper extends deposit insurance valuation in two new directions. First, we present a multiperiod valuation model that generalizes the standard single-period deposit insurance contract. This allows us to estimate the present value of providing deposit insurance for not only the current period, but for subsequent periods as well. It therefore meets the Federal government's requirement of providing a budget forecast of deposit insurance costs for future years. In addition, our method incorporates a number of aspects of bank and regulatory behavior that affect deposit insurance costs but that have not been considered in previous analyses. We use Monte Carlo simulation to compute year-by-year deposit insurance costs.

Second, we illustrate how a bank's net worth can be estimated from reported cash flows so that deposit insurance valuation can be applied to all depositories, and not just those that are publicly traded. Together, these extensions facilitate the budgetary treatment of deposit insurance so that the aggregate costs can be recognized as they accrue, rather than when cash payments are expended. In addition, our framework can be used to judge the efficacy of policy reforms and to estimate fair deposit insurance premia.

APPENDIX A: THE CALCULATION OF CASH FLOWS FOR ESTIMATING BANKS' MARKET VALUES OF NET WORTH

Define

V_t = market value of bank assets at time t.

V_{bt} = book value of bank assets at time t.

D_t = market value of bank deposits at time t.

D_{bt} = book value of bank deposits at time t.

y_t = bank revenues net of loan losses at time t for period of length Δ.

e_t = bank interest and noninterest expenses at time t for period of length Δ.

r = interest rate on competitive default-free bonds.

Using the above, let

$r_{yt} = \frac{y_t}{V_{bt}}$ be the bank's revenue per dollar of (book) assets at time t,

$r_{et} = \frac{e_t}{D_{bt}}$ be the bank's expense per dollar of (book) deposits at time t,

where r_{yt} and r_{et} can be thought of as returns per unit of assets and deposits at time t. Now, we can compute a Tobin's q type measure of the market value of assets and deposits to their book values. The initial book values of assets and deposits, V_{b0} and D_{b0}, can be thought of as the initial amount of funds and deposits, respectively, received by the bank. The ratios of the risk-neutral market values of bank assets and deposits to their initial values can be computed by a present value formula which discounts expected future cash flows per unit of assets and deposits,

$$\frac{V_0}{V_{b0}} = \sum_{t=1}^{\infty} \frac{E_0[r_{yt}]}{(1+r)^t} \tag{A.1}$$

$$\frac{D_0}{D_{b0}} = \sum_{t=1}^{\infty} \frac{E_0[r_{et}]}{(1+r)^t}. \tag{A.2}$$

Using (A.1) and (A.2), we can then compute the bank's market value of net worth,

$$\begin{aligned} V_0 - D_0 &= V_{b0} \sum_{t=1}^{\infty} \frac{E_0[r_{yt}]}{(1+r)^t} - D_{b0} \sum_{t=1}^{\infty} \frac{E_0[r_{et}]}{(1+r)^t} \\ &= \sum_{t=1}^{\infty} \frac{E_0[V_{b0} r_{yt} - D_{b0} r_{et}]}{(1+r)^t}. \end{aligned} \tag{A.3}$$

We may wish to normalize this estimate of the market value of net worth by the bank's book value of deposits so that our estimation of the process for cash flows will be comparable across large and small banks. From (A.3) we have that the market value of net worth to the book value of deposits is

$$\frac{V_0 - D_0}{D_{b0}} = \sum_{t=1}^{\infty} \frac{E_0[V_{b0} r_{yt}/D_{b0} - r_{et}]}{(1+r)^t}. \tag{A.4}$$

Thus, the proper definition of the bank's cash flow, $C(t)$, for estimating its ratio of net worth to deposits at time t is

$$\begin{aligned} C(t) &= V_{b0} r_{yt}/D_{b0} - r_{et} \\ &= \frac{y_t V_{b0}}{V_{bt} D_{b0}} - \frac{e_t}{D_{bt}}. \end{aligned} \tag{A.5}$$

Now assume that $C(t)$ follows the process

$$C(t + \Delta) = \theta + \rho C(t) + \varepsilon_t, \tag{A.6}$$

where the autoregressive parameter $\rho < 1$ is inversely related to the amount of mean reversion in $C(t)$. For example, if $\rho = 0$, $C(t + \Delta)$ would be expected to always equal the constant, θ (complete mean reversion). As ρ approaches 1, $C(t)$ becomes a random walk (no mean reversion). ε_t is assumed to be a normally distributed error term.

The parameters in Eq. (A.6) can be estimated using OLS. Once we have these estimates, the present value of expected future cash flows can be computed. Let r be the annualized discount rate for these cash flows. If we define the present value of net worth per unit of deposits as $W(t)$, then an implication of (A.4) and (A.5) is

$$\begin{aligned} W(t) &= \sum_{j=1}^{\infty} \frac{E_t[C(t + \Delta j)]}{(1+r)^{\Delta j}} \\ &= \frac{\theta + \rho C(t)}{(1+r)^{\Delta}} + \frac{\theta(1+\rho) + \rho^2 C(t)}{(1+r)^{2\Delta}} + \frac{\theta(1+\rho+\rho^2) + \rho^3 C(t)}{(1+r)^{3\Delta}} + \cdots. \end{aligned} \tag{A.7}$$

Define $\pi = (1 + r)^{\Delta}$. Substituting into (A.7) we obtain

$$
\begin{aligned}
W(t) &= C(t)\sum_{j=1}^{\infty}\left(\frac{\rho}{\pi}\right)^{j} + \theta\sum_{j=1}^{\infty}\pi^{-j} + \theta\rho\sum_{j=2}^{\infty}\pi^{-j} + \theta\rho^{2}\sum_{j=3}^{\infty}\pi^{-j} + \cdots \\
&= \frac{\rho}{\pi-\rho}C(t) + \frac{\theta}{\pi-1} + \frac{\theta\rho/\pi}{\pi-1} + \frac{\theta(\rho/\pi)^{2}}{\pi-1} + \cdots \qquad \text{(A.8)} \\
&= \frac{\rho}{\pi-\rho}C(t) + \frac{\theta\pi}{(\pi-1)(\pi-\rho)}.
\end{aligned}
$$

Therefore, our final result is

$$
W(t) \equiv (V_t - D_t)/D_{bt} = \frac{\rho}{\pi-\rho}C(t) + \frac{\theta\pi}{(\pi-1)(\pi-\rho)}. \qquad \text{(A.9)}
$$

Note also that the one-period-ahead variance of $W(t)$ is

$$
\mathrm{Var}_t[W(t+\Delta)] = \left(\frac{\rho}{\pi-\rho}\right)^{2}\sigma_{\varepsilon}^{2}. \qquad \text{(A.10)}
$$

APPENDIX B: COMPARISON OF NET WORTH ESTIMATES TO STOCK MARKET AND FDIC LOSS DATA

As discussed in Section III.B, using data on individual banks' cash flows as well as data on the aggregate market value of (traded) bank shareholders' equity we estimated the parameters of a model that measures the net worth for an individual bank using only its reported cash flow. In this appendix, we present evidence of the accuracy of this cash flow based valuation approach by comparing its net worth measure to two alternative measures. We first examine the difference between the cash flow model's implied theoretical value of shareholders' equity with the market value of shareholders' equity for individual large banks whose stocks are publicly traded. While the parameters of the cash flow based model were estimated, in part, using the *aggregate* market value of shareholders' equity, this does not ensure that the model matches the market value of equity on an *individual* bank level. Hence, this first comparison is clearly of interest. Second, we compare the net worth measure of the cash flow model to that implied by FDIC loss estimates at the time that failed banks are closed.

TABLE VII
COMPARING STOCK MARKET AND CASH FLOW MEASURES OF SHAREHOLDERS' EQUITY

Sampling period	Sample size	Standard deviation	Correlation coefficient	Value-weighted average shareholders' equity		
				Stock market	Cash flow	Error
1985 Q1–1990 Q4	2596	2.6%	0.45	7.7%	7.7%	0.0%
1985 Q4	105	2.4%	0.56	7.3%	6.4%	0.9%
1986 Q4	109	2.4%	0.55	8.1%	8.2%	−0.1%
1987 Q4	109	2.6%	0.33	6.9%	7.5%	−0.6%
1988 Q4	109	2.4%	0.23	7.7%	7.9%	−0.2%
1989 Q4	109	2.4%	0.47	7.7%	8.7%	−1.0%
1990 Q4	110	2.0%	0.58	6.0%	7.6%	−1.6%
1992 Q4[a]	120	2.6%	0.67	11.5%	11.4%	0.1%

[a] Out of sample estimate.

The left-hand side of Table VII presents the standard deviation and sample correlation coefficient between the cash flow model's theoretical value of shareholders' equity–asset ratio (using Eq. (18)) and the actual market value of shareholders' equity–asset ratio for individual banks with publicly traded stocks. These cross-sectional standard deviations and correlation coefficients are computed using end-of-year data over the model estimation period, 1985–1990, as well as the out-of-sample year, 1992. The standard deviations do not appear unreasonable and the correlations for given years, as well as for all of the sample years (1985–90), are consistently positive and moderately high. It is both interesting and encouraging that the highest correlation between our cash flow based measure and that implied by bank stock prices occurs for the out-of-sample year 1992.

The right-hand side of Table VII compares the value-weighted averages of shareholders' equity to assets for the sample of banks for both the stock market based measure and the cash flow based measure. As described in the text, the cashflow model's θ parameter was chosen so as to equate these two value-weighted averages for the full sample period, 1985Q1–1990Q4, and this is indicated by the 0% error in row 1 of the table. However, we also list the difference between these alternative measures for each year's fourth quarter, as well as for the out-of-sample date 1992Q4. The cash flow based model appears to track yearly changes reasonably well. Indeed, the model accurately captures the large change in net worth shown in the stock market from 1990 to the out-of-sample year, 1992.

A second test of the cash flow based net worth estimate is whether it predicts declines in the book value of capital and matches the FDIC's loss estimates for failed banks. See Federal Deposit Insurance Corporation

TABLE VIII
FAILED BANK LOSS ESTIMATE REGRESSION
FDIC loss/deposits = $a_0 + a_1$ (cash flow based loss/deposits)
Standard errors in parentheses

Sample	a_0	a_1	Sample size	R^2
Whole	−0.224	0.277	94	0.146
	(0.029)	(0.070)		
Deposits > $250 M.	−0.166	0.263	44	0.163
	(0.040)	(0.092)		
Deposits $100 M. to $250 M.	−0.277	0.282	50	0.140
	(0.041)	(0.10)		

(1992). For 94 large commercial banks and holding companies that failed between 1985 and 1990, we constructed time profiles of their reported book capital and cash flow based net worth for the 19 quarters prior to their actual failure.[34] A comparison of the total of these banks' reported capital to their total deposits to our estimate of their total net worth to total deposits is graphed in Fig. 2. The widening difference between the two measures of capital illustrates the tendency for the book capital of a failing bank to be a lagging indicator of its condition. Note that our model's

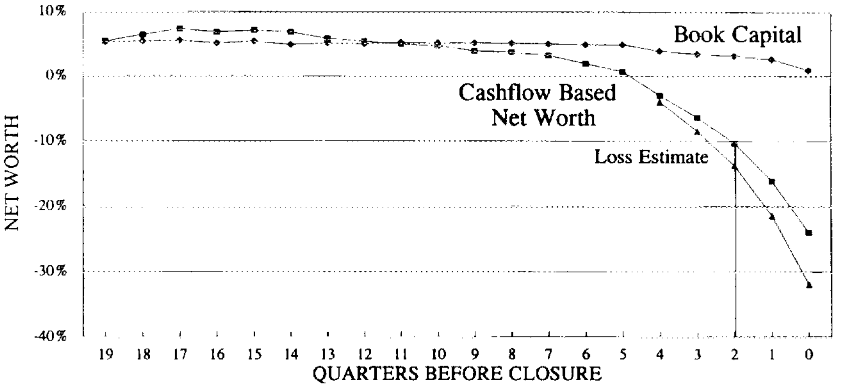

FIG. 2. Bank failures 1985–1990, book capital vs cash-flow-based net worth, based on FDIC closures of banks with over $100 million in deposits. Loss estimate is $(1 + k)$ times cash-flow-based net worth, where $k = 1/3$.

[34] This group of institutions includes all commercial banks with deposits exceeding $100 million that were closed by the FDIC between 1986 and 1990 and for which separate FDIC loss estimates were available.

estimate of these banks' net worths became negative, on average, more than 1 year prior to closure.

Turning to a comparison of our loss estimates versus the FDIC's loss estimates of failed banks, note that our model literally assumes that regulators close banks at the end of a given year, and it uses a bank's year-end cashflow data to estimate the cost of closure (negative net worth) at that date. In practice, however, regulators close banks periodically throughout the year, so that our model's estimate of closing costs will, on average, utilize cash flow data that precedes actual closure by six months. Consequently, we perform our failed bank cost comparison using only cash flow data available six months prior to the FDIC closure date.[35] Using our estimate of bank net worth six months prior to closure and adding on the extra $\frac{1}{3}$ direct closure cost found by James (1991), we arrive at an estimate of total FDIC losses to total failed bank deposits of 15.0%, very close to the FDIC's total loss estimate of 15.1%. Comparing losses on a bank-by-bank basis, our estimate of the average ratio of bank loss to bank deposits of 29.0% is quite close to the FDIC's average ratio of bank loss to bank deposits of 30.4%.[36] We also ran simple regressions with the dependent variable being the FDIC's loss estimate to deposits ratio for a single bank and the independent variable being our cash flow based loss estimate to deposits ratio for the same bank. The results are given in Table VIII. For the full sample, as well as the sample split by bank deposit size, we see that the overall fit, based on the R^2 statistic, is much less than perfect. However, for each sample we find that the cash flow based estimate is positively and significantly related to the FDIC's loss estimate.

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[35] An additional reason for not basing our closing cost estimates on the two quarterly cash flows immediately preceding closure is these cash flows tend to be distorted by regulatory pressure that forces banks to deduct previously reported, but not received, interest income. This results in a sudden decline in total interest income that leads to drastic declines in these final cash flows. Using these final cash flows would tend to give a downward bias to the final net worth estimates of the bank.

[36] Since the loss–deposits ratio is larger, on average, for smaller banks, the average of these ratios is much higher than the ratio of total banks' losses to total banks' deposits.

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